# CLEAN FOSSIL ENERGY— ROLES FOR NATURAL GAS AND COAL

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## INTRODUCTION

During the Sydney conference in 1996, APEC ministers endorsed a set of non-binding energy policy principles with a common goal of achieving economic growth with minimum impact to the environment. These principles promote cost effective measures to ensure efficient use of energy, reduce environmental emissions, and encourage new types of environmentally sound energy technologies.

During the Okinawa Conference in 1998, APEC energy ministers endorsed the recommendations of "Accelerating Investment in Natural Gas Supplies, Infrastructure and Trading Networks in the APEC Region." Natural gas trading networks comprised of internal and cross-border pipelines, LNG terminals and distribution systems were promoted for economic development within APEC economies. At the same time, the "Recommended Work Program on Environmentally Sound Energy Infrastructure in APEC Member Economies" was also endorsed. The Energy Ministers requested the Energy Working Group to develop practical and effective means of implementing environmental policy and practices that will facilitate energy investment.

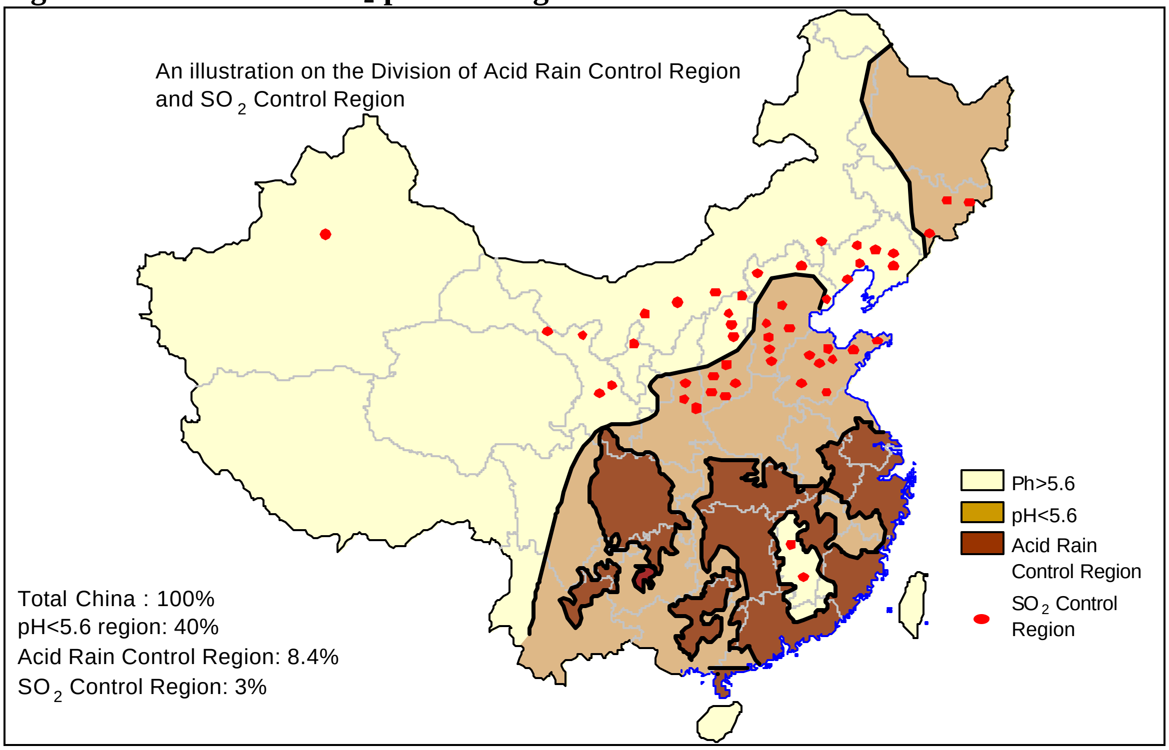
Under the objectives of the Okinawa Conference, the purpose of this paper is to examine the environmental impact and commerciality of natural gas and coal, and the roles they can play in clean fossil energy. The People's Republic of China has been used as an example for this discussion, and the general conclusions from this analysis can be applied to other economies.

### How Serious is the Environmental Problem?

Coal meets more than 30% of the world's primary energy need and is used to produce approximately 40% of the world's electricity. Heavy coal use in conventional coal boilers is a significant contributor to environmental problems. Sulfur dioxide and nitric oxide emissions can cause acid rain, and carbon dioxide emissions can cause global warning. Taking China as an example, approximately 75% of that economy's primary sources of energy come from coal. In 1995, total coal consumption in China was 930 million tonnes, accounting for approximately one-third of the world total (Reference 1). The extensive use of coal has brought with it a severe emissions problem. Figure 1 shows the current distribution of acid rain, as well as areas where sulfur emissions are particularly problematic (Reference 2). More than 40% of land in China suffers from acid rain problems, and 8.4% of land has a pH level less than 4.5. As for sulfur, more than 3% of land in China has emission levels higher than the national standard of 2100 milligrams per cubic meter ($mg/Nm^3$; measured at 6% oxygen); this is despite the fact that the standard is already approximately 10 times higher than that imposed in the European Community countries.

As an economy develops, its pollution problem will only worsen unless there is a fundamental change in the use of primary energy. Since fossil fuels will remain the dominant energy sources in the foreseeable future, it is important to identify ways to utilize these resources cleanly and economically.

**Figure 1. Acid rain and $SO_2$ pollution regions in China**

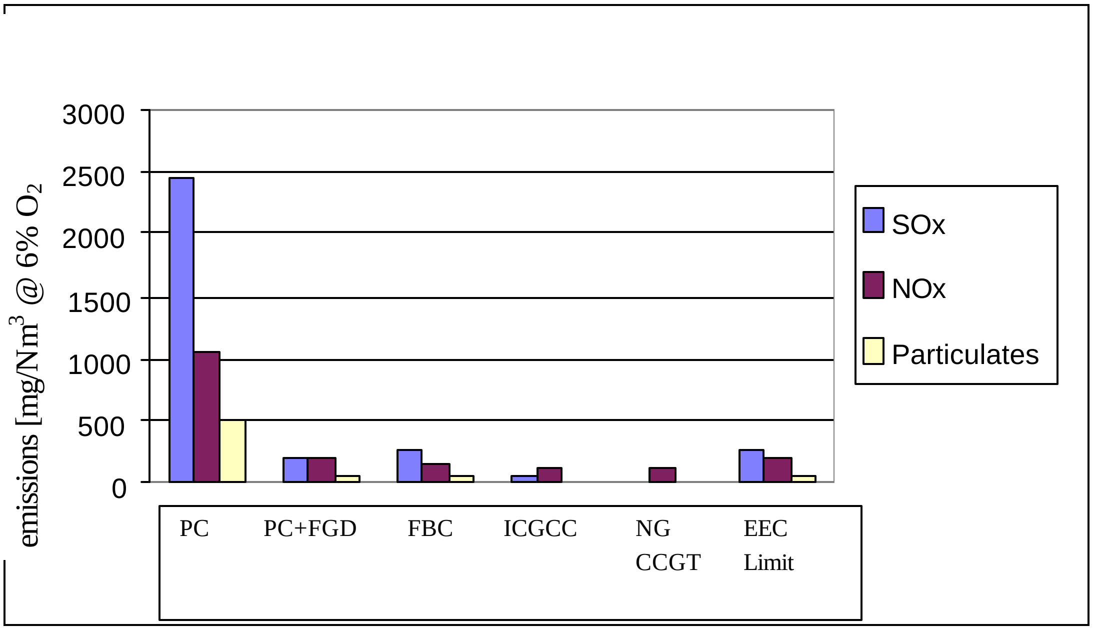



## Environmental Performance of Natural Gas and Coal for Power Generation

Power generation probably causes the greatest environmental impact. Figure 2 compares the environmental performance of conventional coal and natural gas for power generation. Emission abatement methods such as flue gas desulfurization (FGD) or de-NOx facilities can reduce environmental impacts. However, these methods suffer from higher capital costs and reductions in overall efficiency of the power stations where they are used; in the end, more energy is consumed to produce the same output of electricity. Clean coal technologies such as circulating fluidized bed, and Shell's proprietary coal gasification processes, are alternative means of utilizing coal. They have superior plant efficiencies and environmental performance when compared with conventional methods of power generation.

Natural gas, when used in high-efficiency combined cycled gas turbines (CCGT), produces the best environmental performance in this comparison, especially when liquefied natural gas (LNG) is used. This is because natural gas CCGTs produce approximately 30% less carbon dioxide than the most efficient clean coal technology, and LNG contains no sulfur or particulates.

**Figure 2. Comparison of emissions between various technologies (1% S in coal)**




## Economics of Natural Gas

As a fuel, natural gas can only be widely utilized if the end products, such as electricity, can compete effectively with alternative means of fuel sources. As such, the delivery gas price is very important; Figure 3 shows the price comparison between pipeline gas and LNG. Pipeline gas is normally cheaper if the distance between the gas reservoir and delivery point is less than 3,000 km. Beyond that is a region where LNG and pipeline gas both offer similar prices. However, if the gas reservoir is farther than 9,000 km, LNG is normally a cheaper alternative.

Extensive analysis has been performed of break-even gas prices at the burner tip for power generation in China (Reference 3). Coastal and northern regions of China, respectively, can sustain burner-tip gas prices of more than US$5/mmBtu and US$4/mmBtu (Figure 4). Depending on the location of gas consumption, indigenous gas can be supplied economically at these levels. Furthermore, importation of LNG is an economically viable alternative despite its comparatively higher CIF price at the coast. It should also be noted that these break-even prices are compared to existing coal-fired power stations using <1% sulfur without FGD installations. These break-even prices will be higher if such installations are factored into this calculation. This is another argument that natural gas should be utilized immediately in China.

**Figure 3. Cost of Pipeline Gas vs. LNG**

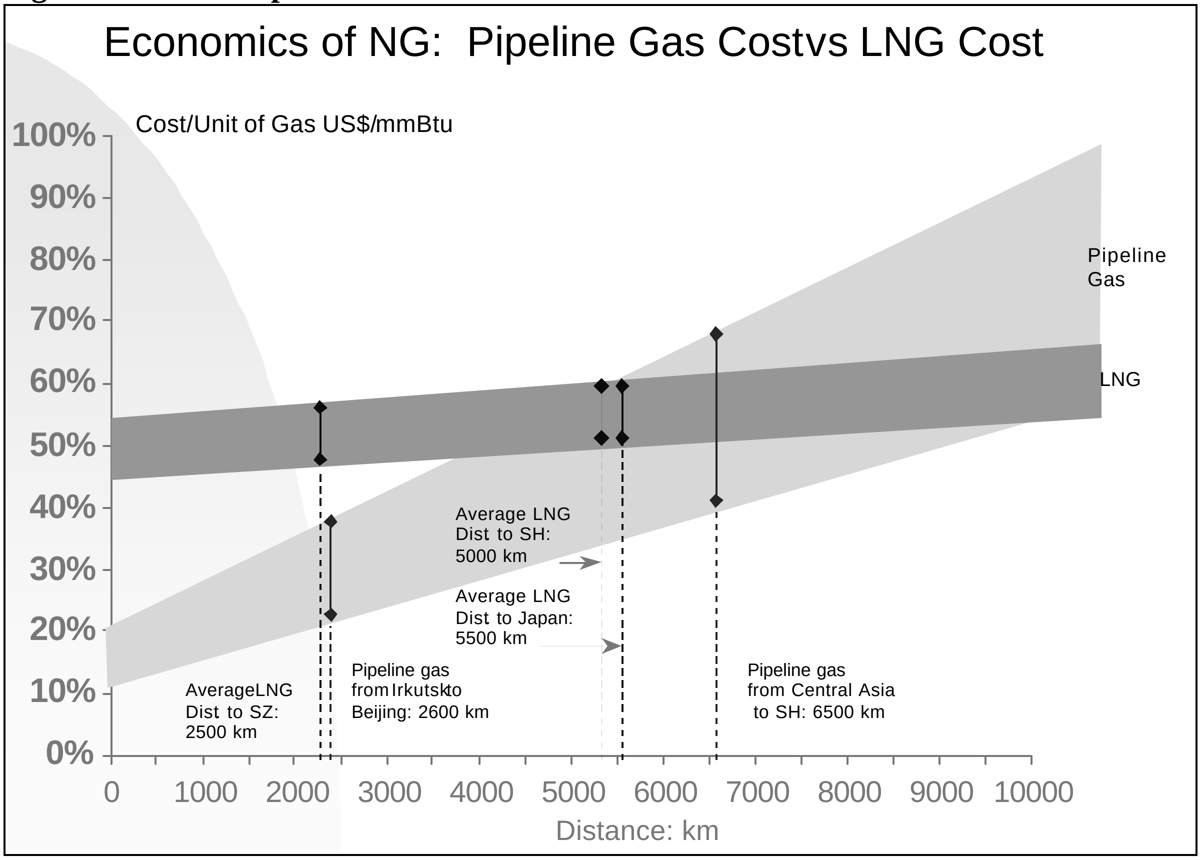
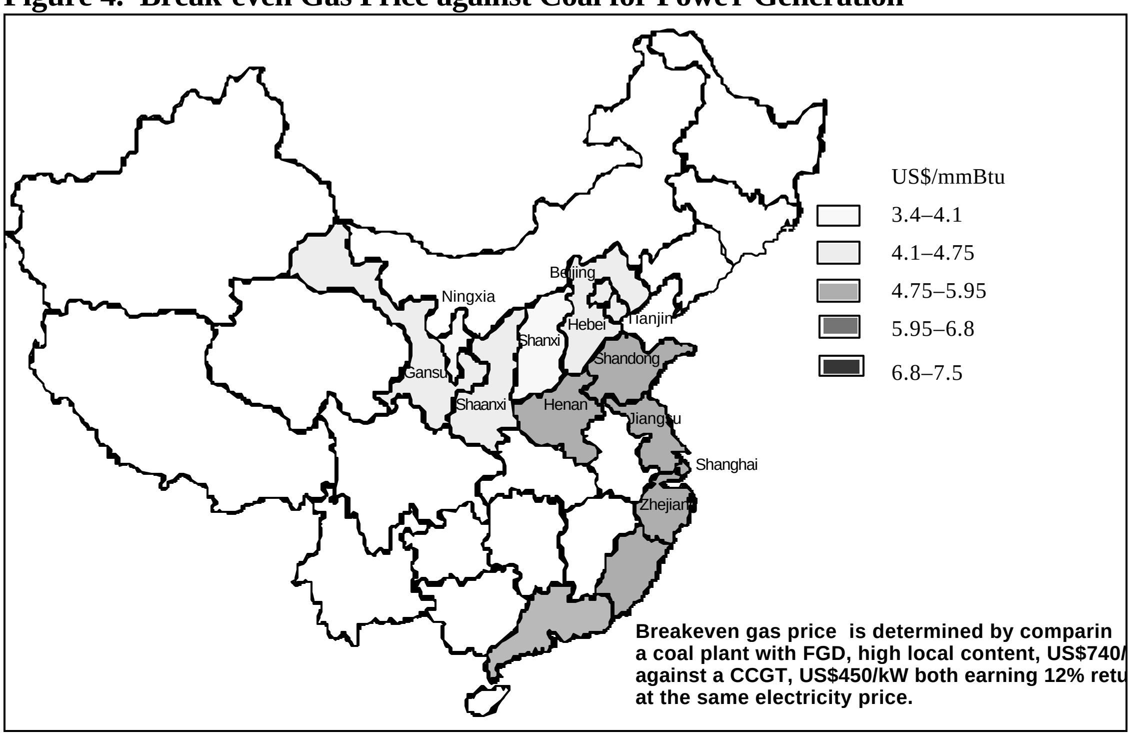



**Figure 4. Break-even Gas Price against Coal for Power Generation**



## Economics of Clean Coal Technologies

There has been a general conception that clean coal technologies are expensive. Krupp Uhde/Siemens, Parsons/US Department of Energy, GE/Foster Wheeler, Electric Power Research Institute (EPRI) and Texaco/Mitsubishi/BOC have all conducted studies to reduce the capital costs of installing integrated gasification combined cycle (IGCC) systems (Reference 4). Their reports show a capital cost ranging between US$1,050/kW and US$1,300/kW depending on size and configuration. If IGCC is to be benchmarked against conventional fired stations with FGD installations to ensure competitiveness, IGCC unit costs should aim to be below US$1,000/kW. A number of methods have been suggested to reduce unit capital costs:

- use the most advanced gas turbines available;
- decrease overhead expenditures such as engineering and project management;
- standardize equipment, and
- rationalize measures for construction and installation.

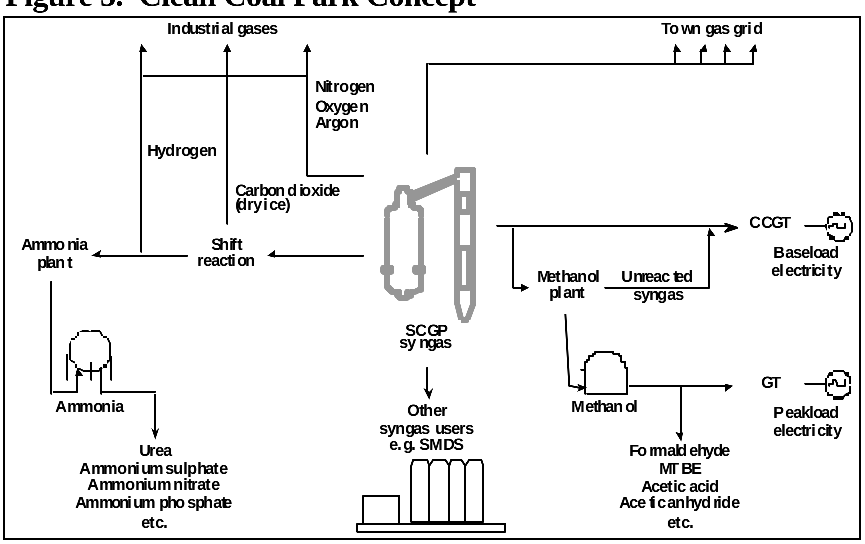
Perhaps the most effective way to further reduce costs is through the following two methods (Reference 5):

### *1. Increasing economy of scale*

Scaling up to 5,000 t/d coal-processing capability (from 2000 t/d) without compromising on performance and reliability. The capital cost of a 5,000 t/d Shell Coal Gasification Process (SCGP) plant can be 30% less than a 2,000 t/d plant, resulting in a 15% reduction in the cost of syngas.

In order to consume the large amount of syngas produced by such a facility, it would be useful to have a number of syngas offtakers located near the SCGP plant. Such offtakers could be power plants, or chemical or industrial plants. This concept of a "clean coal park" is illustrated in Figure 5.

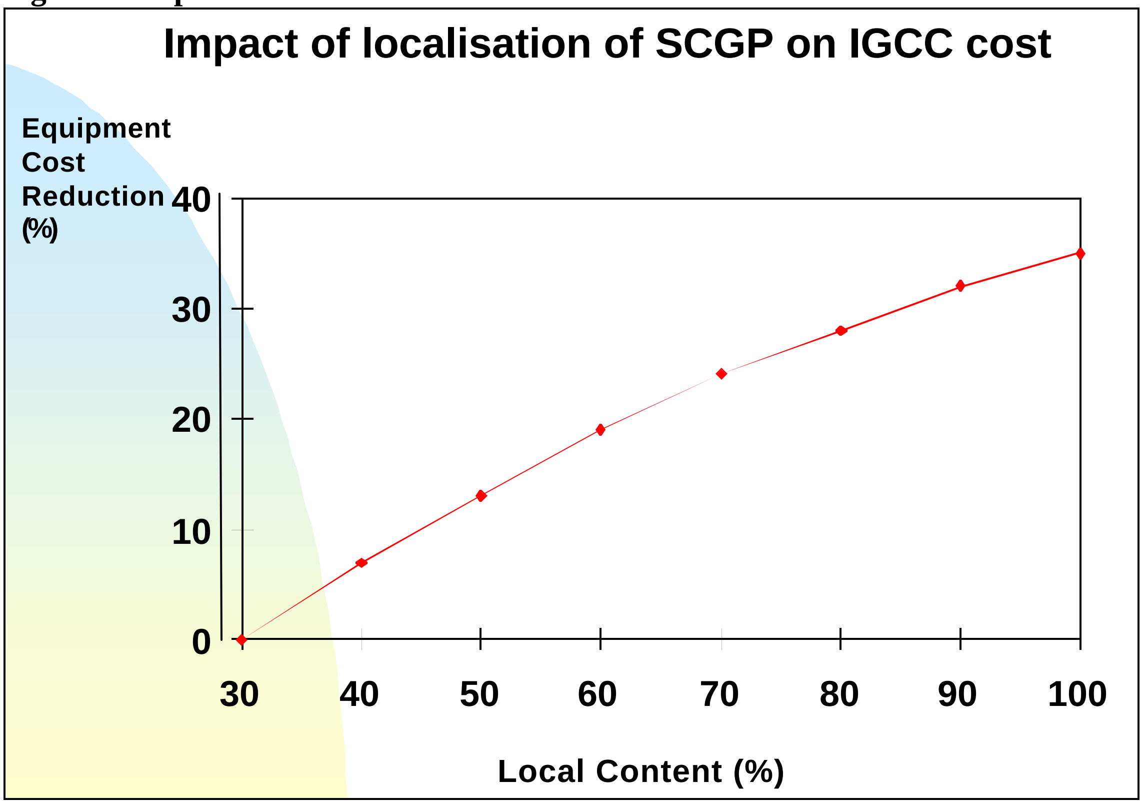
**Figure 5. Clean Coal Park Concept**



*2. Maximizing local content*

Local sourcing and manufacture of equipment in China can reduce unit costs significantly. Extensive consultations with Chinese design institutes and manufacturers have been conducted, and Figure 6 shows the potential impact of local content on equipment costs. These costs could potentially be reduced by 27% for an IGCC plant if local content increases from 30% to 80%.

**Figure 6. Impact of Localization on IGCC**




Focusing on increasing the economy of scale and the proportion of local content, the competitiveness of clean coal technology (using SCGP) is assessed against its alternatives. Figure 7 shows the environmental impact and generating cost comparison between SCGP-IGCC and conventional coal plants using 1% sulfur coal. It clearly demonstrates that IGCC is an effective way to minimize environmental impact, and can be competitive particularly if local content can be maximized.

**Figure 7. Comparison of emissions between various technologies (1% S in coal)**

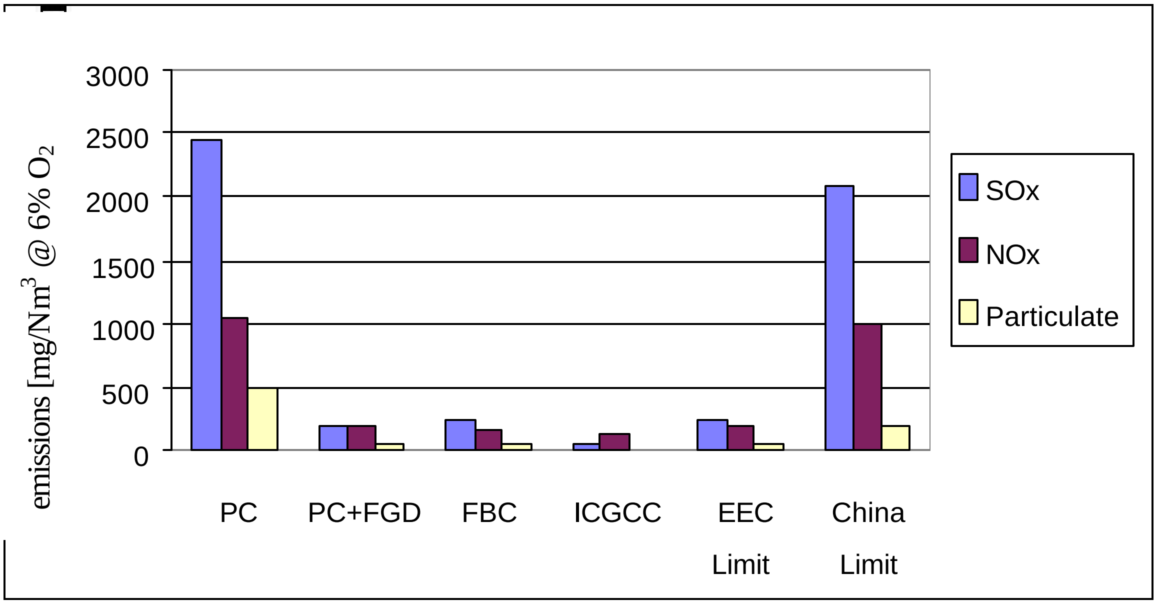
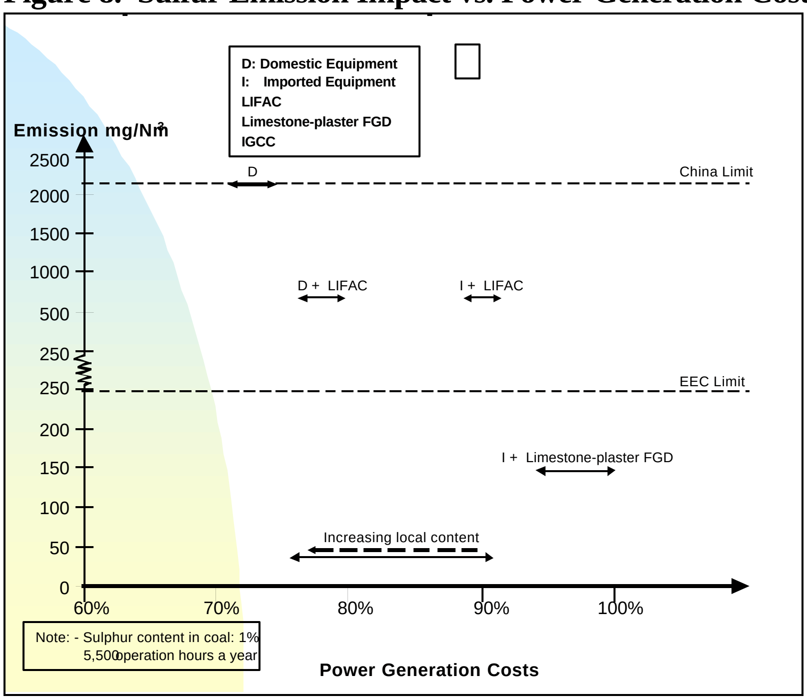



**Figure 8. Sulfur Emission Impact vs. Power Generation Cost**




Syngas can be used as feedstock for chemical products such as ammonia, methanol, acetic acid, acetic anhydride and urea. If syngas can be produced competitively, it can replace either naphtha or natural gas to manufacture these chemical products.

Figures 9 and 10 show the competition between the three types of feedstocks for the production, respectively, of ammonia and methanol.  Zones where SCGP is or is not competitive are marked for both greenfield and retrofit plants.  The 'indifference' zone indicates that SCGP may or may not be competitive depending on the degree and availability of local equipment sourcing.  These figures demonstrate that SCGP may be competitive depending on relative prices of competing feedstocks.

**Figure 9.  SCGP Competitiveness— Ammonia Production**

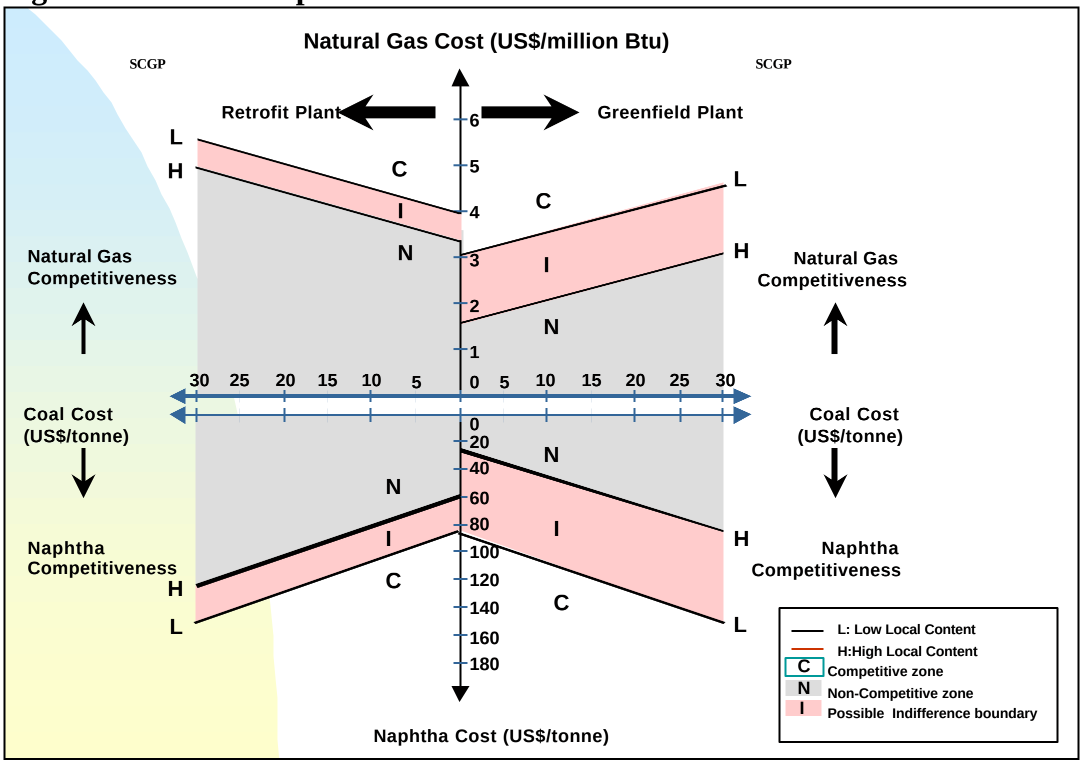
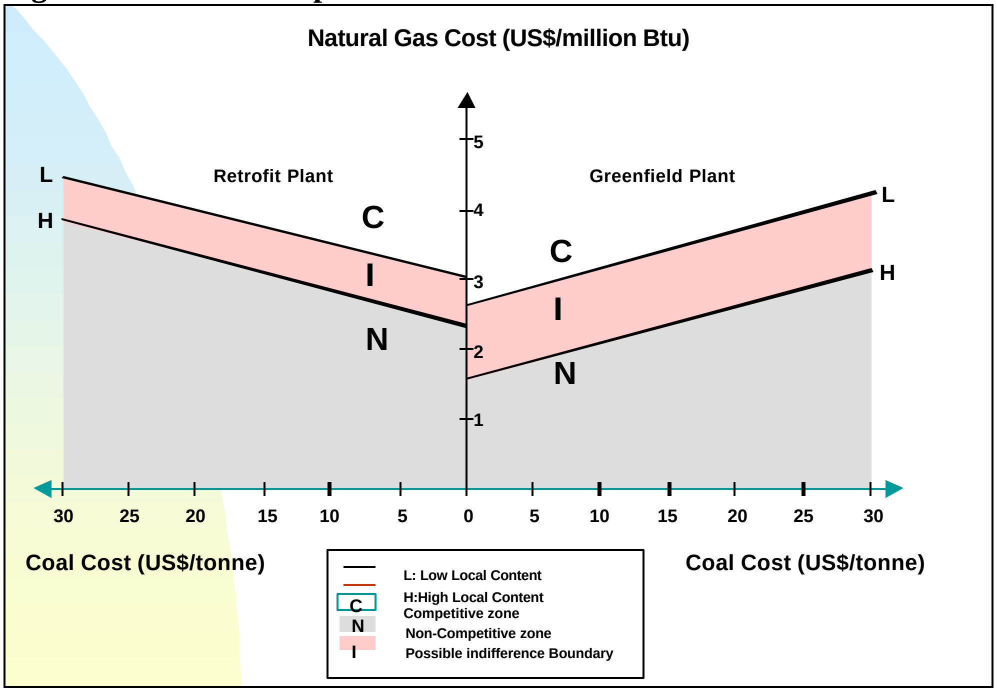


**Figure 10. SCGP Competitiveness - Methanol Production**




## CONCLUSION

Natural gas and clean coal technologies are economically viable methods of satisfying the APEC Energy Ministers' objective of minimizing adverse impacts on the environment. For natural gas, a list of recommendations for the development of gas marketing was presented at the Energy Ministers' Meeting in Okinawa in October 1998 (Reference 6). It is recommended that enabling policies for natural gas be implemented as soon as possible, and that natural gas be used extensively.

Clearly, clean coal technology can also play a vital role in an environmentally sound energy infrastructure. Although present unit costs for clean coal technologies are higher than for conventional technologies, effective ways have been identified to make them competitive. It is recommended that enabling policies similar to those of natural gas be developed by the Energy Working Group. This will help promote clean coal installations and provide a basis on which to use coal in an environmentally caring manner.

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